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A botanical cross-section of northern Mississippi, with notes on the influence of soil on vegetation

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(WITH PLATES 21, 22)

INTRODUCTION

The coastal plain of the southeastern United States seems to be more diversified geographically in Mississippi than in any other state, with the possible exception of Florida; and the correlations between geology and vegetation are more obvious there than in any other part of the coastal plain, unless it is in western Alabama. These interesting correlations were graphically described by Dr. E. W. Hilgard in his epoch-making "Geology and Agriculture of Mississippi" in 1860, in the fifth volume of the Tenth Census reports in 1884, and in his text-book on Soils* in 1906. On pages 490–492 of the book last named there is a special phytogeographical sketch of the northern end of the state, between latitudes 34° and 35°, accompanied by an outline map showing the soil provinces or geographical divisions, and a table giving in very condensed form the chemical and physical characters of the soil and a list of a few of the more characteristic trees in each region.

In the summer of 1911 I had occasion to cross the northern half of Mississippi twice, first a little south of the portion last mapped by Dr. Hilgard, and then almost through the center of it. In so doing I crossed all but two or three of the divisions on his map (which form belts approximately parallel to the Mississippi

* Reviewed in Torreya 7: 170–175. 1907.

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River, instead of to the coast as in most other parts of the coastal plain, and therefore running north and south), and I took advantage of the opportunity to make a more complete analysis of the vegetation of each division than had been attempted in that part of the country before. The observations made on that trip, besides embodying some previously unrecorded facts, have led to some conclusions which seem sufficiently new to be offered to the botanical public.

Previous literature. Besides the works of Dr. Hilgard already noted, and a few papers on particular regions, which will be mentioned farther on, the following have an important bearing on the phytogeographical problems of northern Mississippi.

Campbell & Ruffner. A physical survey extending from Atlanta, Ga., across Alabama and Mississippi to the Mississippi River, along the line of the Georgia Pacific Railway, embracing the geology, topography, minerals, soils, climate, forests, and agricultural and manufacturing resources of the country. 8vo. 147 pp. and 2 folded maps. New York, 1883. (Pages 92–96 and 102–107 relate to Mississippi.)

A. B. Hurt. Mississippi: its climate, soil, productions, and agricultural capabilities. U. S. Dept. Agric. Misc. Spec. Rep. no. 3. 89 pp. 1883?. (Contains an annotated list of trees, among other things.)

Sargent & Mohr. (Forests of) Mississippi. U. S. Tenth Census 9: 530–536, and colored map. 1884.

W. J. McGee. The Lafayette formation (in Mississippi). U. S. Geol. Surv. Ann. Rep. **12**[1]: 451–461. 1892.

L. C. Johnson. (Underground waters of) Mississippi. U. S. Geol. Surv. Water Supply & Irrigation Paper 114: 171–178. *f. 23* (geological map). 1905.

A. F. Crider. Geology and mineral resources of Mississippi. U. S. Geol. Surv. Bull. 283. 99 pp. 1906.

Crider & Johnson. Summary of the underground-water resources of Mississippi. U. S. Geol. Surv. Water Supply & Irrigation Paper 159. 86 pp. 6 plates (including colored geological map), 11 text-figs. 1906.

A. F. Crider. A provisional [*sic*] geologic and topographic map of Mississippi. 20 × 28 in., colored. First published in 1907, and issued in connection with several different bulletins of the Mississippi State Geological Survey.

C. E. Dunston (of the [U. S.] Forest Service). Preliminary examination of the forest conditions of Mississippi. Mississippi State Geol. Surv. Bull. 7. 76 pp. (Not dated, but apparently published two or three years ago).

Some of these publications are more useful to botanists than their titles would seem to indicate. There are very few references to the area under consideration in purely botanical literature, doubtless chiefly because nearly all the plants growing there, as far as known, are widely distributed, as I have already pointed out in the case of northwestern Alabama and the Delaware peninsula,* and can be studied more conveniently elsewhere.

Itinerary. On June 6, 1911, I crossed the eastern boundary of Mississippi at McCrary, in Lowndes County, and continued to Columbus, Artesia and West Point by the Mobile & Ohio R.R. In the next few days I traveled almost due westward from West Point, in about latitude 33° 30′, on the "Southern Railway in Mississippi" (formerly Georgia Pacific Ry.), stopping at Carrollton, Greenwood, Itta Bena, Stoneville and Greenville, and making short excursions on foot from each of these places. On the 10th I crossed the Mississippi River at Greenville by going ten or twelve miles upstream to Luna Landing, Arkansas (the nearest railroad point on the other side), which gave me a view of the banks of the river for that distance. On the 16th I re-entered Mississippi near Mineral Wells, in DeSoto County, traveled southeastward on the Frisco System (formerly Kansas City, Memphis and Birmingham Ry.) to Tupelo, then southward on the Mobile & Ohio to West Point and Artesia, and back to Alabama the same way as before. Over a year later, namely, on August 31, 1912, I came into the state near Corinth, in Alcorn County, traveling southward on the Mobile & Ohio R.R. to Tupelo, West Point, etc. The notes made on this last trip have been combined with those of 1911 in making up the list of plants for one of the regions, as will be explained presently.

Method of treatment. The various soil belts described by Dr. Hilgard are not as easily recognized now as they were when he knew them best, for the increase of population and cultivated fields generally tends to obliterate geographical distinctions. And

* Torreya 7: 44–45. 1907; 9: 217. 1909.

as I crossed the boundaries of most of the regions at the rate of 25 to 40 miles an hour, and without ever having seen them before, I was unable to discern some of the distinctions that have been made by those who have explored the territory on foot and made careful studies of the stratigraphy. In the following pages the results of my superficial study of the more conspicuous vegetation of these belts, as far as I could recognize them, are set forth. Notwithstanding its superficiality, this has one advantage over previous studies of Mississippi vegetation in being quantitative.

Under each belt or region named the geology and topography are briefly described, and the percentages of lime, potash, and phosphoric acid in the soil, taken from Hilgard's report on cotton production in the fifth volume of the Tenth Census, are indicated in nearly every case, for purposes of comparison. Additional literature is cited for some of the regions. All those crossed east of Carrollton and Holly Springs extend southeastward into Alabama, where they have been recently described, with quantitative analyses of the forests of each, in my geographical report on the economic botany of that state (Geol. Surv. Alabama, Monograph 8. 228 pp. June, 1913).

The plants identified in each belt are divided first into trees, shrubs and herbs, and then arranged in order of abundance or frequency, with a number indicating how many times each was seen, except in the case of belts so narrow that the frequency numbers would be too small to have much significance. Species seen not more than once in a distance of fifty miles are usually omitted. The names of evergreens are printed in heavy type and those of vines in italics.

THE REGIONS IN DETAIL

From the Alabama line to about three miles west of Columbus, a distance of about 12 miles, the country is underlaid by the Eutaw formation, one of the divisions of the Cretaceous, but the surface is mostly a sandy loam of much more recent age, presumably the Lafayette.* As the railroad in this short distance crosses the Buttahatchee and Tombigbee Rivers and traverses a few

* A description of this part of Mississippi by Dr. Hilgard can be found in the 5th volume of the Tenth Census, pages 296–298.

miles of the bottoms of the latter, the vegetation visible from the train is mostly that of river-bottoms. And as the soil is so fertile that most of it is under cultivation by this time, there is not much natural vegetation left. Most of the shrubs and herbs seen were introduced species, and it is hardly worth while to enumerate them. The commonest trees seem to be *Pinus Taeda*, *Salix nigra*, *Liquidambar*, *Taxodium distichum*, *Quercus Phellos* and *Ulmus alata*, in the order named.

Cretaceous prairie region. From McIntyre (three miles west of Columbus) to Artesia and West Point, thence westward about to the line between Clay and Webster Counties, the country is characterized by a newer Cretaceous formation, the Selma Chalk or Rotten Limestone, with little or no Lafayette loam over it. On the return trip I entered the same belt near the northeastern corner of Pontotoc County, and traversed it lengthwise from Tupelo to Artesia. This is the "northeastern prairie region" of Hilgard's Mississippi reports, a direct continuation of the central prairie region or black belt of Alabama, which has been well described by Smith,* Mohr,† and several less familiar writers.

This prairie region is gently undulating or "rolling," with very few springs or small streams. Its soil, mostly a gray calcareous clay, was once considered the most fertile in the state, with the possible exception of that in the "delta" (described farther on), and consequently most of it has been long given over to agriculture. Analyses of this soil published by Dr. Hilgard show 0.99–1.37% of lime (CaO), 0.33–0.86% of potash (K_2O), and 0.03–0.27% of "phosphoric acid" (P_2O_5). With the possible exception of corn, cotton always has been the principal crop (about 20% of the total

* Tenth Census **6**: 55–58, 68, 128–140 (pages numbered correctly at bottom). 1884; Geol. of Coastal Plain of Ala. 281–285, 350–352, 533–535, 538–539, 576–577, 585, 605–608. 1894.

† Plant Life of Alabama 97–106. 1901. (This however includes two adjoining belts which were not separated by Dr. Mohr.)

The Mississippi portion of the black belt has been described by Hilgard, Hurt (op. cit., 10–12), and Crider (U. S. G. S. Bull. 283: 17–19), and in the government soil surveys of Monroe, Clay, Lowndes, Oktibbeha and Noxubee Counties. Report no. 96 of the U. S. Department of Agriculture, by H. H. Bennett of the Bureau of Soils, and M. A. Crosby of the Bureau of Plant Industry, on the soils of the prairie regions of Alabama and Mississippi and their use for alfalfa, published late in 1911, contains some interesting descriptions and illustrations of the present condition of the region in both states.

area having been devoted to that crop as long ago as 1880), but in recent years, especially since the approach of the boll-weevil, a great deal of alfalfa has been raised. A large amount of land also is now devoted to pasturage, as in many other parts of the world where agriculture has been long established.

In such a fertile region forests, especially primeval forests, are of course scarce. Some parts of it indeed are said to have been treeless when first discovered, whence the name "prairie"; but it would be hardly possible to determine the location and extent of the original prairie spots with any degree of satisfaction now. However, this is one of the few parts of the South where one can see fields and pastures on the sky-line in many places instead of all woods. The remaining forests are principally of two kinds: oak groves on broad low knolls of poorer soil (Lafayette?), and bottom-land forests near some of the creeks and rivers. The latter doubtless owe their preservation to the fact that the earlier settlers found such land too difficult to drain, and often too insalubrious to live in; but the growing population continually requires more land, and the bottom-land trees are gradually disappearing before the axe of the farmer. Pines are not seen at all in this part of Mississippi, except an occasional solitary specimen of *Pinus Taeda* or *P. echinata*, presumably introduced.

Although very different geologically, and not very similar in climate, there are some striking resemblances between the present appearance of this region and the prairie region of Illinois. Both have comparatively level topography and fertile grayish to blackish clay soil, and streams which fluctuate considerably and are muddy most of the time. Both have very little woodland at the present time (they were much less alike in this respect before the country was settled, though), and almost no evergreens. Luxuriant corn-fields make up a large part of the summer landscape (in Illinois the crop is nearly all corn, but in Mississippi it is about half cotton), and finally in both regions the population is about as dense as extensive agriculture alone will support, and consequently it is practically at a standstill outside of the manufacturing cities.

Just as in the Cretaceous region of New Jersey and Delaware,* the herbaceous flora recognizable from a train consists mostly of

* See Bull. Torrey Club **37**: 425. 1910; Torreya **12**: 221. 1921.

weeds; but even the weeds are rather characteristic of this region, both in Mississippi and in Alabama. The following list of plants is derived from 128 miles of travel through the prairie region in 1911, and from 69 miles over part of the same route (viz., from Tupelo to Artesia and McIntyre) in 1912. The country between Corinth and Tupelo, traversed on the 1912 trip, although mostly underlaid by the same formation, is not taken into consideration in the statistics because it has much more of the superficial sandy loam (Lafayette?), a difference which is strongly reflected in the vegetation. The figures for the two years are kept separate, because one set of observations was made in early summer and one in late summer, which makes a considerable difference in the aspect of the herbaceous vegetation. The first figure in each case is for June, 1911, and the second for August, 1912. Species seen less than three times in traveling these 197 miles are omitted.

TREES

24+7 Quercus stellata
21+5 Salix nigra
15+10 Populus deltoides
18+3 Liquidambar Styraciflua
15+5 Quercus Phellos
13+5 Quercus falcata?
8+3 Quercus marylandica
7+3 Platanus occidentalis
6+4 Hicoria ovata?
7+0 Ulmus alata?
5+2 Celtis sp.
4+2 Quercus nigra
3+3 Quercus pagodaefolia
6+0 Gleditscha triacanthos (introduced?)
5+0 Toxylon pomiferum (introduced)
5+0 Quercus alba
5+0 Hicoria alba?
4+2 Quercus lyrata?
3+0 Fraxinus sp.
3+0 Morus rubra
2+1 Cercis Canadensis
1+2 **Juniperus virginiana**

SHRUBS

19+4 Prunus angustifolia
13+1 Sambucus canadensis
4+5 Cephalanthus occidentalis
7+1 *Brunnichia cirrhosa*
6+0 *Tecoma radicans*
3+2 Rhus glabra
2+2 Sassafras variifolium
3+0 *Smilax glauca*
3+0 Rubus sp.
2+1 **Arundinaria macrosperma**

HERBS

31+18 Sorghum Halepense
37+6 Melilotus alba
18+18 Tripsacum dactyloides
5+21 Ambrosia trifida
24+0 Anthemis Cotula
8+15 Helenium tenuifolium
20+0 Daucus pusillus
0+19 Ambrosia bidentata
19+0 Plantago aristata
10+4 Acuan illinoense
1+9 Chaetochloa sp.
6+4 Ambrosia artemisiaefolia
0+9 Eupatorium serotinum
0+8 Paspalum sp.
8+0 Apocynum cannabinum
0+7 Chamaecrista fasciculata
6+0 Monarda citriodora
6+0 Ratibida pinnata
4+2 Silphium laciniatum
0+6 Vernonia sp.
5+0 Cicuta Curtissii
0+5 Syntherisma sanguinalis
0+5 Bidens sp.
0+5 Xanthium sp.
5+0 Lepidium virginicum
4+0 Boltonia asteroides
4+0 Asclepias tuberosa
4+0 Rumex sp.
2+2 Typha latifolia
0+4 Solidago sp.
0+4 Croton capitatus
0+4 Carduus sp.
3+0 Andropogon scoparius
3+0 Cyperus pseudovegetus
0+3 Conoclinium coelestinum
0+3 Silphium terebinthinaceum
0+3 Gaura Michauxii
0+3 Sporobolus indicus

Assuming the above figures to represent correctly the relative abundance of the species, less than 2% of the woody plants (i. e., individuals, not species) are evergreen. The significance of this fact will be discussed farther on.

The oaks in this region, as in the "delta" region to be described below, are rather puzzling, especially to one who has never seen them before and has no opportunity to stop and examine them closely in the light of descriptions or specimens. Dr. Hilgard* has described some curious forms of oaks in this very region, which ought to be investigated by a competent taxonomist. The comparatively large number of herbs, and the occurrence of a few genuine prairie species, such as *Ambrosia bidentata*, *Silphium laciniatum*, *S. terebinthinaceum*, *S. perfoliatum*, *Mesadenia tuberosa*, and *Polytaenia Nuttallii* (the last three seen only once, and therefore not listed), are reminders of the prairie conditions that once existed in this region.

Pontotoc Ridge. The next younger formation in Mississippi is the Ripley, the uppermost division of the Cretaceous. Its strata are more sandy and therefore less easily eroded and dissolved than the Rotten Limestone, and they give rise to a belt of hills, rather rugged for the coastal plain, known in Mississippi as the Pontotoc Ridge. According to Dr. Hilgard's analyses its soil contains 0.17–0.28% of lime, 0.15–0.37% of potash, and 0.08–0.11% of phosphoric acid; or approximately half as much of these important materials as in the prairie belt.† The Ripley formation and its corresponding topography are wanting in the latitude of Columbus and Greenville, but on the return trip I traversed it for about 15 miles, between New Albany and Sherman.

Although the soil of the Pontotoc Ridge is perceptibly less fertile than that of the neighboring prairies, it is mostly under cultivation now, and one does not get a very accurate idea of its native vegetation by merely crossing it once on a fast train. In the following list the numbers are omitted, because they would be too small to have much significance.

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* Soils 491, 494, 498–502.

† For descriptions of this part of Mississippi see Hilgard, Geol. & Agric. Miss. 83–92. 1860; U. S. Tenth Census 5: 221–223, 292–294. 1884; and the U. S. soil survey of Pontotoc County by Bennett and Winston, 1907.

TREES	SHRUBS
Salix nigra	Sambucus canadensis
Liquidambar Styraciflua	Robinia Pseudacacia
Cornus florida	Prunus angustifolia
Pinus echinata	Sassafras variifolium
Platanus occidentalis	Rhus glabra
Quercus alba	HERBS
Quercus falcata	Asclepias tuberosa
Cercis canadensis	Tripsacum dactyloides
Liriodendron Tulipifera	Cicuta Curtissii
Populus deltoides	Sorghum Halepense
Quercus marylandica	(and several less frequent weeds)
Quercus stellata	

A noteworthy difference between this list and the one next preceding is the presence of *Pinus echinata** and *Liriodendron*, species which do not grow in the richest soils. I am not sure that any of the shrubs and herbs listed could have been found in prehistoric times in the places where I saw them.

Post-oak flatwoods. The oldest Eocene formation in Mississippi underlies the "post-oak flatwoods," which lie immediately west of the Pontotoc Ridge in Union County and of the prairie region in Clay County, and extend southeastward into Alabama. This belt is nowhere more than 15 miles wide, and where I crossed it on the westward trip its boundaries seemed so ill-defined, that I could not very well separate my notes on it from those on adjacent regions. On the way back, however, I had little trouble in locating its western edge near Hickory Flat, and its eastern edge at the western base of the Pontotoc Ridge, near New Albany.

The Lafayette formation seems to be absent in the flatwoods, and the Eocene strata have weathered into a very stiff clay, containing, according to Dr. Hilgard's analyses, 0.08–0.18% of lime, 0.25–0.75% of potash, 0–0.05% of phosphoric acid, and 0.17–0.85% of magnesia. Both its physical and its chemical properties make this soil ill adapted to agriculture, and the region is very thinly settled. This part of Mississippi has been described by Hilgard,† Hurt,‡ and E. J. Hill,§ and in the government soil surveys of Pontotoc, Clay and Oktibbeha Counties.

* Prof. Sargent's map of the pine forests of Mississippi (opposite page 530 of the 9th volume of the Tenth Census) does not indicate the occurrence of any pine at all in this region.

† Geol. & Agric. Miss. 273–288; Tenth Census 5: 224–227, 294–296.

‡ Op. cit., 12–14.

§ Torreya 6: 231–232. 1906. In this interesting paper, based on observations made in Oktibbeha County in 1858, the post-oak flatwoods west of Starkville are

Hickory Flat and New Albany are only 14 miles apart, and between those points I had less than twenty minutes in which to gather the following list of plants.

TREES

Pinus echinata
Quercus stellata
Liquidambar Styraciflua
Salix nigra
Fagus grandifolia
Quercus Phellos
Quercus marylandica
Quercus falcata

SHRUBS

Sambucus canadensis
Rhus glabra
Arundinaria sp.
Cephalanthus occidentalis
Tecoma radicans

HERBS

Sorghum Halepense
Helenium tenuifolium
Typha latifolia
Erigeron ramosus
Tripsacum dactyloides
Rudbeckia hirta
Scirpus Eriophorum

This list is too short to draw many important conclusions from, but the fact that a pine stands at the head is significant. The second tree, *Quercus stellata*, is the one which gives the region its name. Forests of very similar aspect can be seen in the "barrens" of extreme northern Alabama and in the Paleozoic flatwoods of the Coosa valley in Georgia and Alabama.

Eocene red hills. The more hilly portions of the Eocene (i. e., excluding the flatwoods) are traversed by the Southern Railway from the eastern part of Webster (formerly Sumner) County to Carrollton, and by the "Frisco" from the Mississippi River to Hickory Flat. Geologists subdivide the Eocene into several formations, but with the exceptions named above and below, I was not able to correlate these with any marked differences in topography or vegetation. The Southern Railway keeps pretty close to a small river nearly all the way across Webster County, and that probably makes more difference in the appearance of the country between that county and those immediately west of it than the difference in age of the underlying rocks does. West of a line drawn from about Holly Springs to Carrollton, though, the Eocene is covered by a superficial formation which affects the vegetation enough to warrant a geographical separation.

called pine-barrens, evidently on account of the contrast with the pineless prairie region bordering them on the east. (The "*Aletris obovata*" mentioned, judging from the description given, and a specimen which I have since seen in the author's herbarium, seems to have been wrongly identified. The locality is several hundred miles from any known station for that species, and in a very different kind of country.)

The typical Eocene country of northern Mississippi is moderately hilly, with reddish to yellowish clayey soil, some of it derived from the weathering of the Eocene strata, and some belonging to the much more recent Lafayette. According to Dr. Hilgard's analyses these soils contain 0.05–0.09% of lime, 0.09–0.24% of potash, and 0.02–0.09% of phosphoric acid; which is a smaller percentage of the first two than in any other region here described. Like most other parts of northern Mississippi, it is now mostly under cultivation, and primeval forests are scarce. The same belt extends northward into Tennessee and eastward to South Carolina, if not farther.*

The following plants were noted more than once in Webster and Montgomery Counties and the eastern half of Carroll on June 7th, or between Holly Springs and Hickory Flat on the 16th; a total distance of 77 miles.

TREES

32 **Pinus echinata**
21 Liquidambar Styraciflua
21 Salix nigra
9 Taxodium distichum
7 Liriodendron Tulipifera
7 Quercus Phellos
7 Quercus falcata
6 **Pinus Taeda**
6 Quercus marylandica
5 Quercus alba
5 Cornus florida
4 Quercus nigra
3 Carpinus caroliniana
3 Fagus grandifolia
3 Platanus occidentalis
2 Quercus stellata
2 Ulmus alata
2 Quercus Michauxii
2 Populus deltoides
2 Cercis canadensis
2 Castanea dentata

SHRUBS

18 Sambucus canadensis
13 Prunus angustifolia
5 *Brunnichia cirrhosa*
5 Rhus glabra
3 Alnus rugosa
3 Rhus copallina
2 Rubus sp.
2 Cephalanthus occidentalis
2 Robinia Pseudacacia

HERBS

15 Plantago aristata
11 Rubdeckia hirta
8 Anthemis Cotula
7 Physostegia sp.
7 Erigeron ramosus
5 Daucus pusillus
4 Sitilias caroliniana
4 Saururus cernuus
4 Cicuta Curtissii
3 Sorghum Halepense
3 Helenium tenuifolium
3 Cyperus pseudovegetus
3 Asclepias tuberosa
3 Boltonia asteroides
3 Juncus aristulatus
2 Tripsacum dactyloides
2 Eryngium yuccaefolium
2 Koellia flexuosa
2 Rhexia lanceolata?
2 Typha latifolia
2 Ambrosia artemisiaefolia
2 **Juncus effusus**
2 Panicum scoparium
2 Cracca virginiana

* For descriptions of this part of Mississippi see Hilgard, Tenth Census **5**: 231–235, 301–302; and the U. S. soil survey of Montgomery County. For notes on the South Carolina end of the same belt see Bull. Torrey Club **37**: 411. 1910; **38**: 225. 1911.

The pines are probably relatively more abundant now than they were originally, on account of their tendency to spread in old fields, so that the apparent proportion of evergreens among the woody plants (19 per cent) may be too large. But it is very evident that the soil of this region is better adapted to evergreens than is that of most of the other regions discussed in this paper. Ericaceae seem to be entirely absent, and native monocotyledons are not conspicuous. (There is no telling how many of the shrubs and herbs listed are really indigenous here, but probably not more than half.) Of the species enumerated, *Taxodium* and *Brunnichia* are almost confined to the coastal plain, and *Quercus Michauxii* and *Populus deltoides* mainly so as far as the southeastern states are concerned; but the other species are pretty widely distributed.

Yellow loam region. Between Memphis and Holly Springs the topography is much the same as in the region just described, but the surface is covered with a few to several feet of loess, a buff-colored very fine-grained somewhat calcareous silt,* which makes the vegetation considerably different. This is the "yellow loam region" or "brown loam table-lands" of Hilgard, which has no counterpart anywhere to the eastward. Dr. Hilgard's analyses show in this soil 0.24–0.25% of lime, 0.30–0.55% of potash, 0.07% of phosphoric acid, and 0.31–0.48% of magnesia.

Almost every acre of it, except on the immediate banks of streams, has been cultivated at some time or other, and much of it is now badly gullied. No primeval forests were seen, and no shrubs or herbs other than weeds, but probably nearly all the trees listed below grew in the same region in prehistoric times, even if not in exactly the same places where they are now. The following list covers 44 miles, about 12 of which were in Tennessee, but so close to the Mississippi line as not to cause any appreciable error.

TREES	
12 Salix nigra	3 Liquidambar Styraciflua
7 Quercus falcata	2 Platanus occidentalis
5 Quercus marylandica	2 Gleditschia triacanthos
4 Quercus stellata	2 Diospyros virginiana
	2 Quercus alba

* For descriptions of this soil see the works of Hilgard and McGee mentioned near the beginning of this paper, also Hilgard, Am. Jour. Sci. **91**: 319–321. 1866; T. O. Mabry, Jour. Geol. **6**: 273–302. 1897.

TREES (continued)

1 Quercus nigra
1 Quercus Michauxii
1 Taxodium distichum
1 Quercus velutina
1 Liriodendron Tulipifera

SHRUBS

12 Prunus angustifolia
11 Sambucus canadensis
3 *Tecoma radicans*
3 Sassafras variifolium
3 Robinia Pseudacacia
1 Rhus glabra

HERBS

5 Plantago aristata
3 Rubdeckia hirta
2 Sorghum Halepense
2 Asclepias tuberosa
1 Tripsacum dactyloides
1 Daucus pusillus
1 Euphorbia sp.

Quercus nigra is partly evergreen (probably less so here than nearer the coast, though), but with this possible exception no evergreens were seen. Ericaceae and Cyperaceae are likewise rare or absent.

Bluff region. Carrollton is near the brow of a line of bluffs which border the flood-plain of the Mississippi River all the way from Memphis to Vicksburg, and form one of the most prominent topographic features in Mississippi. From Carrollton station (North Carrollton P. O.) the railroad descends rapidly for six or eight miles to the foot of the bluffs, following the valley of a creek. I walked the railroad from North Carrollton to Malmaison, which is near the edge of the flood-plain, and from there northward up into the bluff hills about two miles and back.

Geologists generally map the surface formation of these bluffs ("cane hills," they are called farther south) as loess, but what I saw of it in Carroll County looked almost exactly like the "second bottom" loam along many rivers in the coastal plain of Alabama, and quite different from the more typical loess which I saw a few days later in Arkansas, and between Memphis and Holly Springs. The steeper slopes of the bluffs are strewn in many places with subangular cherty pebbles.

The plants seen along and near the railroad and creek between Carrollton and Malmaison are mostly species characteristic of bottom-lands, as follows.

TREES

Taxodium distichum
Liquidambar Styraciflua
Salix nigra
Platanus occidentalis
Cercis canadensis
Carpinus caroliniana
Betula nigra
Morus rubra
Quercus Michauxii
Acer Negundo
Quercus lyrata
Juglans nigra
Liriodendron Tulipifera
Populus deltoides
Ulmus spp.

SHRUBS

Sambucus canadensis
Cephalanthus occidentalis
Brunnichia cirrhosa
Arundinaria macrosperma
Hydrangea quercifolia
Ampelopsis cordata
Rhus glabra
Hydrangea arborescens
Rosa carolina
Itea virginica

HERBS

Cicuta Curtissii
Saururus cernuus
Juncus effusus
Commelina hirtella
Carex triangularis?
Homalocenchrus oryzoides
Onoclea sensibilis
Carex lupulina?
Spirodela polyrrhiza
Panicum scoparium
Teucrium sp.
Diodia teres*
Euphorbia corollata
etc.

Up on the hills north of Malmaison the vegetation is much like that of ordinary dry woods at moderate altitudes throughout the South, as the following list shows.

TREES

Pinus echinata
Quercus marylandica
Cornus florida
Quercus falcata
Quercus stellata
Quercus alba
Hicoria alba
Quercus coccinea

SHRUBS

Ceanothus americanus
Hydrangea quercifolia

HERBS

Cracca virginiana
Pteridium aquilinum
Meibomia laevigata
Meibomia Michauxii
Koellia flexuosa
Psoralea pedunculata
Antennaria plantaginifolia
Polystichum acrostichoides
Mitchella repens
Dioscorea villosa

Judging from the vegetation, the soil of these hills must be considerably less fertile than that of the same line of bluffs farther south, as described by Dr. Hilgard (who apparently never visited Carrollton and vicinity). *Pinus echinata*, the commonest tree, does not seem to have been reported from this part of Mississippi at all before. It seems never to grow on loess (according to Call, Geol. Surv. Arkansas **1889**[2]: 184. 1891), or in any other very rich soil. This and several other species in the list can stand frequent forest fires, but *Hydrangea* and the three evergreen herbs and two vines grow mostly in ravines, where they are pretty well protected from fire.

The "Delta" (PLATE 21). Next is the "Yazoo delta" or Mississippi bottom. Many of its features can be matched fairly well in

* On sand-bars along the creek between Carrollton and North Carrollton. This species grows in quite a variety of habitats, mostly unnatural, but they all have at least one character in common: exemption from fire.

the flood-plains of smaller rivers, but they are here exhibited on a far larger scale than anywhere farther east. On the Mississippi side the "delta" extends from a few miles north of the northern boundary of the state down to Vicksburg, nearly three degrees of latitude, or 200 miles in a straight line, and has its maximum width of 60 miles about midway, or just in the latitude where I crossed it. Generally speaking, it is a vast plain, sloping gently southward, at a rate of about a foot to the mile, traversed by numerous crooked, sluggish, muddy rivers and bayous, whose banks are usually a little higher than the interstream areas. The larger rivers of the delta, such as the Yazoo and Sunflower, are thirty or forty feet deeper at high water than at low water, have a perceptible current, and are navigable for steamboats most of the year, while the smaller bayous are stagnant much of the time, and fluctuate comparatively little. At least 90% of the area is or has been subject to occasional inundation from the spring floods of the Mississippi River ("Father of Waters"), but the building of levees along the banks of the great river, in the last half century or so, has considerably restricted the overflows.

The soil is mainly a fine gray silt, coarsest on the banks of the larger streams, where the current in times of flood is swiftest. Analyses published by E. A. Smith and E. W. Hilgard show that it contains 0.26–1.35% of lime, 0.30–1.10% of potash, and 0.11–0.30% of phosphoric acid. This is one of the most fertile soils known, according to Dr. Hilgard (Soils, 116, 345), and very little commercial fertilizer has been used on it as yet. Most of the area seems to be under cultivation now (cotton being the principal crop), but there is still considerable primeval forest with splendid hardwood timber.*

There is much valuable information about this region in Humphreys and Abbot's voluminous government report on the physics and hydraulics of the Mississippi River, 1861 (reprinted with additions in 1876). Other references are: E. A. Smith, Proc. A. A. A. S. **20**: 251–262. 1872; C. G. Forshey, Proc. A. A. A. S. **21**: 78–111. 1873; Hilgard, Tenth Census **5**: 85–88, 241–247, 319–321. 1884; Campbell & Ruffner, op. cit. 93–96, 105–107;

* I saw only the middle of the delta, but from all accounts the northern half seems to be most extensively cultivated, and forests consequently more prevalent in the southern half.

Hurt, op. cit. 19–24. The latest paper on the area under consideration is Bulletin 244 of the Office of Experiment Stations, United States Dept. Agriculture, a "Report on the Belzoni* drainage district in Washington County, Mississippi," by H. A. Kipp, 1912. This comprises 55 pages, a map and several diagrams; and from the list of bench marks occupying the last six pages one can get a crude idea of the trees of the region and their relative abundance.

Running north and south near the middle of the "delta" is a narrow low ridge, described by Smith and Hilgard as the "dogwood ridge," and said to be above the reach of all floods. Where I crossed it, about Itta Bena, this ridge seems to be only a few inches high, and it would be hardly noticed by any one not making a special search for it. Even the inhabitants of that neighborhood who were interviewed on the subject seemed never to have heard of it. (It is doubtless more noticeable farther north.) I walked along or near the ridge from Sheppardtown to Itta Bena, eight miles, but the vegetation along there did not seem different enough from that of the rest of the region to be listed separately.

The following plants were seen more than once on June 7th to 9th, inclusive, from the train between Malmaison and Greenville, and on side trips on foot from Itta Bena, Elizabeth and Stoneville, a distance of about 75 miles in all.

TREES

31 Taxodium distichum
26 Liquidambar Styraciflua
25 Salix nigra
18 Gleditschia triacanthos
17 Populus deltoides
12 Ulmus alata?†
11 Quercus pagodaefolia
10 Quercus Phellos
7 Nyssa uniflora
6 Diospyros virginiana
5 Quercus Michauxii
4 Platanus occidentalis
4 Quercus nigra
4 Fraxinus sp.
4 Celtis sp.
4 Acer rubrum tridens?
3 Planera aquatica
3 Quercus lyrata
3 Ulmus americana?
2 Morus rubra
2 Carpinus caroliniana
2 **Ilex opaca**
2 Nyssa sylvatica
2 Hicoria ovata
2 Quercus texana?

SHRUBS

25 *Brunnichia cirrhosa*
18 **Sabal glabra**
6 Sambucus canadensis
5 **Arundinaria macrosperma**
3 Cephalanthus occidentalis
3 *Tecoma radicans*
2 *Rhus radicans*
2 **Bignonia crucigera**
2 *Berchemia scandens*
2 Adelia acuminata

* Also (perhaps more commonly) spelled Belzona.

† Some of this may be *Ulmus crassifolia*, which I was not acquainted with at that time.

HERBS

14 Anthemis Cotula
4 Daucus pusillus
4 Sorghum Halepense
3 Cyperus pseudovegetus
3 Dracopis amplexicaulis
2 Carex Crus-corvi
2 Ambrosia artemisiaefolia
2 Saururus cernuus
2 Monarda citriodora

There are probably few places in temperate regions where one can see more species of trees in traveling a similar distance through an essentially homogeneous region. Six of those listed are oaks, and if I had been more familiar with the Mississippi valley representatives of that genus I might have identified still more. The only evergreen tree in the list is *Ilex opaca*,* and that is confined to the highest and driest spots, and constitutes considerably less than 1 per cent of the arboreal vegetation. As in other hardwood regions,† the woody plants greatly outnumber the conspicuous native herbs. The abundance of woody vines seems to be characteristic of alluvial habitats and some other rich soils, in various parts of the world.‡ The herbs listed are nearly all weeds.

Taxodium distichum, the commonest tree, is not found on the banks of the navigable streams of the delta, for it apparently cannot stand more than ten or twelve feet of average seasonal fluctuation of water.§ It abounds along the smaller bayous or "lakes," and in the interstream swamps described by Smith, Hilgard and others. At the time of my visit the branches of most of the cypress trees in this region and among the bluffs near Carrollton had many branches dead at the tips. The cause of this condition was not ascertained, but drainage operations may have had something to do with it.

Populus heterophylla, which is said by Sargent‖ to be especially abundant in this region, I saw only once, and that in the outskirts of the city of Greenwood, where it might not have been indigenous.

Besides the species to be noted presently as conspicuous by their absence all the way across the state, the following were not seen at all in the "delta":

* This seems to be the only angiospermous evergreen tree in New England and in several interior states.

† See Bull. Torrey Club **37**: 411–412. 1910.

‡ See Torreya **10**: 62. 1910.

§ See Science II. **36**: 760–761. 28 No 1912.

‖ Silva N. A. 9: 164. 1896.

Terrestrial ferns
Pinus (all species)
Juniperus virginiana
Alnus rugosa
Fagus
Quercus stellata
Quercus falcata
Quercus marylandica
Liriodendron
Sassafras
Nyssa biflora

Banks of the Mississippi (PLATE 22). Of the banks of the "Father of Waters" I can say very little, having seen them only for a few miles, between Greenville, Miss., and Luna Landing, Ark., on June 10th. Nuttall passed by there in January, 1820, and published some observations on the river-bank vegetation in his "Journal of travels into the Arkansa territory" the following year. Lyell traversed part of the same route in March, 1846, and his observations can be found in his "Second visit to the United States," 2: 163–164. 1849.

On the inner sides of bends *Salix nigra* (?) is seen everywhere on sand-bars between high and low water marks, and *Populus deltoides* on more silty soil a little higher up. These trees can probably stand as much seasonal fluctuation as any in the world. They seem to prefer soils poor in nitrogen and rich in inorganic plant foods, and they must be regarded as the pioneers for that particular type of soil. On the outer sides of bends, where the river is eroding its banks, *Liquidambar*, *Arundinaria*, and various other species characteristic of river-bottoms are visible, together with occasional specimens of *Taxodium* in the swamps farther back.

CONCLUSION

Notable absentees. Of the plants which are common in other parts of the coastal plain and rare or absent in northern Mississippi the following occur to me. *Nyssa biflora* was seen only twice, once in Clay County and once in Lowndes; and *Juniperus* was seen only once on the 1911 trip, that in Lowndes County. (It is rather common in the black belt of Alabama.) Ferns are rare, as are nearly all pine-barren plants. The following were not seen at all.

Pinus palustris
Taxodium imbricarium
Tillandsia*
Orchidaceae
Myrica cerifera
Magnolia (all species)
Ericaceae

* In crossing the "delta" I must have been pretty close to the range of *Tillandsia usneoides*, for Nuttall (Travels, 228), in floating down the Mississippi on Jan. 22,

Relation of flora to precipitation and soil texture. The absence of *Taxodium imbricarium*, *Magnolia glauca*, and other bog plants from northern Mississippi is correlated with the seasonal distribution of rainfall, among other things. In the greater part of the coastal plain, summer is the rainy season; but in the "Mississippi embayment" portion, which is farthest inland, the winters are wetter than the summers, just as in the interior hardwood region, of which this might be regarded as forming a part. At Water Valley, Yalobusha County, which is pretty close to the center of the northern half of Mississippi, meteorological records for a period of twenty years show that only 30.3 per cent of the normal annual precipitation comes in the four warmest months, June to September, and 41.9 per cent in the six warmest months, May to October.* (March is usually the wettest month and October the driest.)

This type of seasonal distribution of rainfall makes all streams, and the ground-water too, high in spring and low in fall; while in the pine-barren portions of the coastal plain the greater evaporating power of the sun in summer is largely counterbalanced by the increased rainfall at that season, and consequently the water-level is much more uniform there, and conditions are favorable for the development of peat and of bog plants. Ponds and swamps are scarce in northern Mississippi, except in the "delta," where they are caused by the topography, in spite of the climatic conditions just described.

Another factor perhaps still more important in determining

1820, first met it at Cypress Bend, about 20 miles below the mouth of the Arkansas River; and one of the bends near Greenville is named "Spanish Moss Bend." The same plant was reported from along the Cumberland River in Stewart County, Tennessee, by Dr. J. M. Safford, state geologist of Tennessee, in Garden & Forest **3**: 81. 1890.

* For data of seasonal distribution of rainfall in some other parts of the coastal plain see Bull. Torrey Club **37**: 415–416 (footnote). 1910; Florida Geol. Surv. Ann. Rep. **3**: 215. 1911. The interior hardwood region has been briefly defined in Torreya **12**: 146. 1912. The map by Gannett there referred to shows for the whole United States the percentage of rainfall for "the six warmer months, April to September inclusive." But in most places in the eastern United States October is usually a little warmer than April; and furthermore it is usually drier than April in the regions that have dry summers, and wetter than April in the regions that have wet summers, so that the figures for May to October give greater contrasts than do those for April to September.

the character of the flora of northern Mississippi is the prevalence of clayey soils, contrasting strongly with the sand of the pine-barrens nearer the coast. Sand is here chiefly confined to the beds of creeks and rivers, as it is in most of the interior hardwood region. The character of the soil may not be wholly independent of the seasonal distribution of rainfall, but it would be too much of a digression to discuss the matter here. Suffice it to say that it happens that in the Eastern United States most regions with wet winters and dry summers have fertile clayey soils, and where the reverse is true sandy soils predominate.

Some relations of vegetation to soil chemistry. Dr. Hilgard, in his earliest and latest books (1860 and 1906), and in various other works, has always stressed the importance of chemical composition of soil, especially the percentage of lime, in determining the character of the vegetation. In his "Soils," page 490, as already noted, he gives the lime percentages for each soil belt of northern Mississippi, and describes the corresponding vegetation briefly. Similar correlations have been made in Europe by a number of investigators, and the fertility of calcareous soils has been long proverbial. Limestone is one of the commonest and most easily recognized minerals, so that such correlations are easily made; but in the light of the observations made on this trip, and other recent investigations, it is highly probable that some of the other mineral ingredients of soils which do not manifest themselves so conspicuously may be equally important to vegetation.

In the case of lime there always has been a difference of opinion as to just how much of it a soil should contain to be called calcareous. According to Dr. Hilgard, in Europe a soil is not usually called calcareous unless it effervesces with acid, which requires about 5% of lime (calculated as CaO)*; while in this country many soils containing only 1% of lime differ as much in their vegetation from those which have less as they do from some derived from nearly pure limestone. He concludes that calcareous soils are distinguished better by their vegetation than by any arbitrary chemical standard; but here another difficulty is encountered. Just what is calciphile vegetation?

Various European investigators, Schimper† for example, have

* In this connection see Plant World 15: 300–301. 1912.

† See pages 94–106 of his Plant Geography, English edition. 1903.

published lists of calciphile plants for particular regions, and in temperate eastern North America certain plants, mostly trees, have become by common consent, as it were, accepted as indicators of calcareous soils. Dr. Hilgard lists quite a number of these in each of his books, and even goes farther and distinguishes different forms of the same species characteristic of different kinds of soil. But none of these writers seem to mention any characters which their calciphile plants have in common, so that if a person totally ignorant of mineralogy should travel around the world he could identify the limestone regions only by knowing the individual species which have been listed as calciphile; and the flora changes almost completely every thousand miles or so in temperate regions.

As a matter of fact, the supposed lime-loving trees listed by Hilgard and others in this country do have some characters in common. They are all deciduous except the cedar (and I have recently shown that that is not necessarily calciphile*), and many of them have durable dark-colored heart-wood, thin leaves, and large seeds. But trees with similar characters, and indeed most of the same species, can be also found in many places where the soil is poor in lime or at least not commonly regarded as calcareous, and associated with other species which have not been hitherto regarded as calciphile. Coville in his work in Arkansas a quarter of a century ago found that the difference in the vegetation of sandstone and limestone areas in close proximity was more quantitative than qualitative; i. e., the species were nearly the same, but their relative abundance differed considerably in the two areas.†

Comparatively few observations on calciphile vegetation in tropical and cold-temperate regions seem to have been made. In Schimper's Plant Geography less than a page (380) is devoted to the effects of lime on vegetation in the tropics, and he believes its influence to be less there than in temperate regions. In extreme southern Florida, including the Keys and most of the mainland south of Miami, the rock is nearly all limestone,‡ and there

* Torreya **12**: 145–154. 1912.

† See Arkansas Geol. Surv. Rep. **1888**[4]: 246–247. 1891.

‡ I have no analyses of the mainland rock, but that of the Upper Keys is said to be over 90% calcium carbonate.

is very little soil on top of it. But almost none of the trees regarded as calciphile in the states farther north are found there, and the question arises, are the numerous species of trees growing on limestone in South Florida (nearly all of them tropical) true calciphiles? They are certainly very different in aspect from the supposed lime-loving trees of Mississippi, being nearly all evergreen. Furthermore, some of the commonest species, the pine especially, flourish equally well in sandy soils a little farther north, which are very poor from an agricultural standpoint.

Let us see now if there is not some soil ingredient other than lime which is of fundamental importance to vegetation. One of the most convenient and at the same time perhaps the most significant characters of arboreal vegetation that can be expressed quantitatively is the percentage of evergreens, and this has been already indicated roughly for most of the soil belts described above. The percentages of certain soil ingredients also have been given, and it will be noticed that in the regions under consideration the evergreens can be correlated with *potash* just about as well as with lime, evergreens being scarcest in the soils richest in potash. This relation is still more apparent when we compare northern Mississippi, where nearly all the soils are pretty well supplied with potash, with Florida, where soil conditions are very different. Florida has a larger proportion of evergreens than any other state in the Union, and at the same time its soils are poorest in potash, though fairly well supplied with lime.* It is altogether likely that the limestones of South Florida above mentioned are deficient in potash, though I have too few data on this point as yet. Statistics collected by Hilgard in his book on Soils show that the percentage of potash in tropical soils is usually less than in those of temperate regions; and it is barely possible that the prevalence of evergreens in the tropics may be due partly to this fact, and not to climate alone, as has been hitherto supposed. In temperate

* On page 11 of Bulletin 85 of the U. S. Bureau of Soils, published late in 1912, there is a table of the average chemical composition of the soils of each state, based on over a thousand analyses. The average of 88 samples from Florida is 0.03% of potash and 0.31% of lime. The corresponding figures for four typical hardwood states are as follows: Kentucky, 92 samples, 0.35% potash, 0.18% lime; Ohio, 57 samples, 0.25% potash, 0.29% lime; Tennessee, 144 samples, 0.28% potash, 0.20% lime; West Virginia, 14 samples, 0.53% potash, 0.16% lime.

FIGURE 1

FIGURE 2

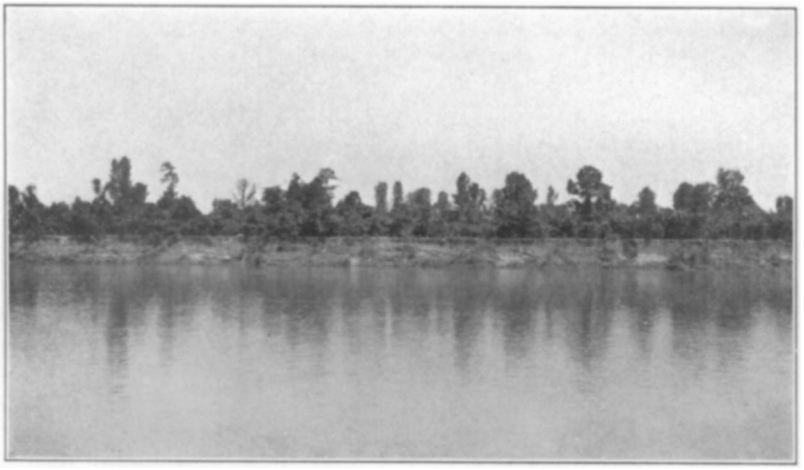

FIGURE 3

FIGURE 4

climates evergreens abound in and near peat bogs and are scarce in clayey soils, and it is well known that potash is scarce in peat and abundant in clay.

Just why potash should be antagonistic to evergreens is an ecological problem that need not be discussed here; for at present I am merely pointing out the geographical correlation. The reasons why this correlation has not been made before are probably first because potassic rocks are not conspicuous and identifiable at sight like limestone, and second because the percentage of potash in the soil varies between much narrower limits than does that of lime, and most soils in inhabited regions have enough potash for the average plant. But it has been proved by many experiments that in an artificial soil containing no potash at all nothing will grow; and it is therefore reasonable to assume that between this artificial condition produced in the laboratory and natural soils containing an average amount of potash there must be intermediate stages where the vegetation is very different from what it is on the average soil. As potash seems to be more abundant in leaves than in any other part of a plant it is natural that a deficiency of this substance should manifest itself first in the leaves, and that plants which do not have access to much potash should have smaller leaves than those of rich soils, and keep them longer.

GEOLOGICAL SURVEY OF ALABAMA, UNIVERSITY

Explanation of plates 21, 22

FIG. 1. Level dry woods about two miles north of Sheppardtown, Leflore County, approximately on the "dogwood ridge." The most conspicuous trees are *Nyssa sylvatica* (in foreground), *Quercus nigra*, and *Ilex opaca*. June 8, 1911.

FIG. 2. Bayou at Quito, Leflore County, looking west from wagon bridge. Trees mostly *Taxodium distichum* and *Nyssa uniflora*. The dead branches in the water indicate the absence of current. June 8, 1911.

FIG. 3. Eroding bank of Mississippi River on outer side of bend about two miles above Greenville, Washington County. Shows *Taxodium distichum*, *Populus deltoides*, *Salix*, etc. June 10, 1911.

FIG. 4. Nearer view of same (eastern) bank of river a little farther upstream, showing numerous vines, *Platanus occidentalis*, etc. June 10, 1911.